# DISCUSSION

The cumulative impacts of land-use practices over the past century, including timber harvest, agriculture, and urbanization, have significantly modified the natural landscape characteristics of Juanita Creek basin, thereby altering many processes that maintain the natural structure and function of this aquatic ecosystems. Due to increased population, development has emerged as the most significant land-use in the basin today. The effects of watershed urbanization on aquatic resources are well documented and include extensive changes in basin hydrologic regime, channel morphology, and physiochemical water quality (Leopold 1968, Hammer 1972, Hollis 1975, Klein 1979, Arnold et al. 1982, Booth 1991, May et al. 1997, May and Horner 2000). The cumulative effects of these alterations on natural ecosystem structure and function have produced an in-stream habitat that is considerably different from that in which salmonids and other aquatic biota have evolved. In addition, development pressure has degraded riparian forests and wetlands, which are an integral component of stream ecosystems (Richey 1982, Steward 1983, Scott et al. 1986, Booth 1990, Booth and Reinelt 1993, May et al. 1997, Horner and May 1999). Parameters measured in this study suggest that urbanization has induced changes in hydrology, channel morphology, riparian integrity and instream habitat quality in the Juanita Creek basin.

## Riparian Corridor

Riparian forest cover in the Juanita Creek basin is substantially diminished from pre-settlement conditions, although deciduous forest was the dominant vegetation in segments 3-5. The riparian vegetation has changed from the natural coniferous dominated forest cover to landscaped areas, grasses, shrubs, and various invasive species (Figure 4). Those areas where riparian forest still occurs are typically dominated by small diameter deciduous species including red alder, willow and big-leaf maple. The absence of mature trees, especially conifers (western red-cedar, western hemlock, Douglas-fir) in riparian areas reduces potential for LWD recruitment into streams (Table 2). Lack of LWD is also results in poor instream habitat quality and diversity (Sedell et al. 1984, Andrus et al. 1988, Murphy and Koski 1989, Beechie and Sibley 1997).

These assessments did not quantify stream buffer width. However, the Watershed Company (1998) determined that stream buffers along the mainstem varied from 10 to 50 feet in the developed areas. Current recommendations for buffer widths on streams are one site potential tree height, which is the average maximum height a climax tree may grow (approximately 170 ft in the PNW) (FEMAT 1992).

## Channel Morphology

With increased surface water-dominated hydrology, streamflow tends to increase for a given storm event, and the duration of high-flow events also increases (Booth 1991). The resultant higher peak flows and more frequent bankfull, channel-altering events increase streambank erosion, bedload transport, and streambed scour (Leopold 1968). Urbanizing streams tend to “over-widen” or incise as a result of more frequent bankfull flows (Dunne and Leopold 1978). Mean BFW:BFD ratios of Juanita Creek were between 3 and 10 (Table 6), which are within the range of “properly functioning conditions” (< 10), and indicates that this stream is not “over-widening.” Armoring, however, was noted in the streambank stability data as well as the field notes, which may suggest that the stream may be prevented from over-widening by bank hardening, and may in fact be incising. A comparison of these data to historical data may reveal whether such changes in channel morphology are occurring.

## Streambank Stability

Some streambank armoring to protect properties from damage by high storm flows is present in all segments (**Error! Reference source not found.**), although the percentage of banks rated unstable or armored was low in all segments, except segment 1. Basin urbanization and loss of riparian vegetation are two factors that contribute to erosion and instability of streambanks (Booth 1991, Booth and Reinelt 1995, May et al. 1997). Riparian vegetation stabilizes streambanks and minimizes streambank erosion, the roots of riparian vegetation and LWD provide the bulk of this function (Bilby and Likens 1980). Besides vegetative cover, other stream corridor characteristics, such as soil-type and valley hillslope gradient, also contribute to the potential stability and current condition of the banks.

## Large Woody Debris

The assessed Juanita Creek segments were severely depleted of LWD. All segments had LWD frequencies much lower that even the *low end* of published ranges for natural conditions in the PNW (range: 150-670 pieces/ km, (Ralph et al. 1994, Murphy and Koski 1989, calculated from Beechie and Sibley 1997). In general, small natural stream channels in the PNW tend to contain an abundance of LWD (Naiman and Bilby 1998). Large woody debris performs critical functions in forested lowland streams, including flow energy dissipation, streambank protection, streambed stabilization, sediment storage, and providing instream cover and habitat diversity (Keller and Swanson 1979, Bilby 1984, Harmon et al. 1986, Bisson et al. 1987, Gregory et al. 1991). Large woody debris in low-gradient pool-riffle or plane-bed streams like Juanita Creek has the greatest range of functional influences (Bilby and Ward 1989, 1991, Montgomery et al. 1995). The physically induced biological influences of LWD are substantial. Fish populations have been shown to decline rapidly following LWD removal (Bryant 1983, Hicks et al. 1991).

Numerous studies have found LWD recruitment potential depends heavily on riparian corridor quality and size (Murphy and Koski 1989, Van Sickle and Gregory 1990, Johnson and Ryba 1992, Fetherston et al. 1995, Rot et al. 2000). Although relatively high percentages of forested riparian reaches occurred in segments 3 through 5 of this assessment, natural levels of instream LWD was not present in these segments. This emphasizes that numerous mechanisms of LWD loss are operating in Juanita Creek, including transport downstream or out of the channel due to high storm flows, and removal by streamside residents. Large woody debris is typically quite low in PSL urban streams (May et al. 1997) and Juanita Creek is no exception.

## Pool Habitat

The quantity of pool habitat in Juanita Creeks segments 1-4 meets NMFS' pool frequency standards (NOAA 1996), but the riparian vegetation does not provide an adequate source of LWD for recruitment to the stream. This results in an "at risk" rating from the Matrix of "properly functioning conditions." Segment 5 did not meet pool frequency standards or LWD recruitment standards and received a "not properly functioning" rating. The majority of pools in Juanita Creek were shallow and low quality, most likely due to cumulative effects of urbanization, such as changes in the natural hydrologic regime, reduced LWD recruitment. Pool frequency and depth has been shown to be directly proportional to LWD frequency, in addition, surface area and cover-quality are also directly related to LWD quantity and quality (Andrus et al. 1988, Robison and Beschta 1990, Ralph et al. 1994).

Field notes from these assessments observe occasional "nice gravels," but more frequently observe the presence of unstable sand and fines in the streambed (Table 7). In general, these data suggest that degradation of spawning gravels may be occurring. A more quantitative study of stream substrate could determine this more conclusively.

## Invasive Species

Invasive species were found in the riparian corridors in all assessed segments of Juanita Creek (Table 4). In general, fragmentation and encroachment of the riparian corridor has provided pathways for invasive and exotic species, especially plants. Himalayan blackberry (*R. discolor*) and field bindweed (*C. arvensis)* are the most common invasive species along Juanita Creek, and dominate some of the riparian corridor. Of particular concern is the presence of Policeman's Helmet (*I. glandulifera*), which is a relatively new invasive in King County. In Britain, where the climate is similar to the Pacific Northwest, this plant is considered extremely invasive and is one of the "top 20" non-native weeds. A single plant can produce up to 800 seeds, which are viable for 18 months or more and can even germinate under water. Since the plant often grows along streams and ditches, seeds can be quickly spread downstream (http://dnr.metrokc.gov/wlr/LANDS/Weeds/Mpatiens.htm). While many of these invasive plants found in Juanita Creek may provide some beneficial functions to the stream (shade, detritus, bank stabilization, etc.), they are undesirable because, among other reasons, they are not a source of LWD and prevent native riparian species from becoming established in extensive areas.

## Water Quality

Increased water temperatures and decreased dissolved oxygen levels are consistent with the effects of urbanization, and can be detrimental to salmonid and other aquatic life adapted to well oxygenated waters. Specific conductivity in urbanized streams and wetlands tends to be over 100 µS (May et al. 1997, Horner et al. 2001). Metro data (1986-1993) and from this study (2000) reveal conductivities greater than 150 µS in Juanita Creek, except in 1990 and 1992 when specific conductivities were 130 and 114, respectively. Elevated conductivity occurs in urbanized watersheds most likely because of ions from concrete and other materials associated with urbanization are leached into the groundwater (May et al. 1997). Continued water quality monitoring designed to capture changes in temperature and dissolved oxygen over the years would be beneficial to further determine habitat quality of Juanita Creek.

## Biology

References that describe pre-development salmon runs in Juanita Creek are difficult to find. A 1948 report on spawning in Juanita Creek mentions that a few coho, kokanee, and cutthroat occurred in the stream. This is presented as declined productivity due to urbanization (Fisheries 1948). In a short Washington Department of Game report in 1968, Juanita Creek was described as a previously productive salmonid stream, but was then currently essentially non-productive (Ward 1968).

Results from other studies of Juanita Creek that were designed to evaluate fish presence help to detail current use of Juanita Creek by various fish species. According to a study recently conducted by The Watershed Company (*Kirkland's Streams, Wetlands and Wildlife Study*, July 1998), Juanita Creek supports both coho salmon and cutthroat trout. During this electrofishing study done from February 19 to March 17, 1998, juvenile coho were captured as far upstream as King County's Edith Moulton Park (~RM 2.0), and adult cutthroat spawners[1] were seen even farther upstream. No fish of any kind were detected upstream of I 405 (~RM 2.5) (The Watershed Company 1998). The Washington Dept. of Fisheries Stream Catalog (1975) noted that coho and sockeye utilized the mainstem. Volunteer data from the SalmonWatcher program provides information about use of the stream by spawning salmon. Eight volunteer Salmon Watchers saw 16 sockeye and 19 kokanee in the mainstem of Juanita creek in 2000 (Vanderhoof 2001b). The one volunteer who watched Juanita Creek in 1998 and 1999 saw no salmon (Vanderhoof 2001a).

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[1] These were identified as sea run cutthroat by the consultants. The criteria on which this identification was based is unknown.

Salmonids were observed in all of the segments assessed in Juanita Creek. The dates that the juvenile salmonids were seen in Juanita Creek are after sockeye and kokanee leave their natal streams, which suggests that these fish are either coho salmon or cutthroat trout.